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VERIFICATION OF TRANSLATION

I, Moon-Jah KANG of 9Fl., Seoyoung Bldg., 158-12, Samsung-dong, Kangnam-ku, Seoul, 135-090, Korea, declare that I have a thorough knowledge of the Korean and English languages, and the writings contained in the following pages are correct English translation of the specification and claims of Korean Patent Application No. 2002-60705.

This 10th day of March, 2005

By:

[Moon-Jah KANG]

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This is to certify that the following application annexed hereto

is a true copy from the records of the Korean Intellectual Property Office

Application Number : PATENT-2002-0060705

Date of Application : October 04, 2002

Applicant(s) : LG. Philips LCD Co., Ltd.

COMMISSIONER

[BIBLIOGRAPHICAL DOCUMENTS]

[TITLE OF DOCUMENT] PATENT APPLICATION

[CLASSIFICATION] PATENT

[RECIPIENT] COMMISSIONER

[REFERENCE NUMBER] 0001

[SUBMISSION DATE] 10. 04. 2002

[TITLE OF INVENTION IN KOREAN] 위상변이 레이저 마스크 및 이를 이용한 순차측면고상 결정화 방법

[TITLE OF INVENTION IN ENGLISH] Phase Shift Laser Mask and sequential lateral solidification Crystallization Method using by the same

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[APPLICANT CORD] 1-1998-101865-5

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[ATTORNEY CORD] 9-1998-000534-2

[ALL-INCLUSIVE AUTHORIZATION REGISTRATION NUMBER] 1999-001832-7

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[EXAMINATION REQUEST] Request

[PURPORT] We submit application as above under the article 42 of the Patent Act and request of examination as above under the article 60.

Attorney Jung, Won-Ki (seal)

[FEES]

[BASIC APPLICATION FEE]	20 pages	29,000	won
[ADDITIONAL APPLICATION FEE]	9 pages	9,000	won
[PRIORITY FEE]	0 thing	0	won
[EXAMINATION REQUEST FEE]	22 claim	813,000	won
[TOTAL]		851,000	won

[ENCLOSED] 1. Abstract, Specifications (with Drawings) - 1 set

[DOCUMENT OF ABSTRACT]

[ABSTRACT]

The present invention relates to a phase shift laser mask for fabricating a crystallization silicon using a laser apparatus having a complete melting energy intensity includes: a base substrate; a plurality of phase shift layers having a first width along a first direction on the base substrate, the plurality of phase shift layers spaced apart from each other; a plurality of laser blocking layer overlapped the plurality of the phase shift layers along the first direction, the plurality of the laser blocking layers including a second width narrower than the first width; and a slit in an interval space between the plurality of the phase shift layers, thereby increasing productivity by the SLS crystallization process through improved resolution of the laser beam.

[REPRESENTATIVE FIGURE]

FIG. 7

[SPECIFICATIONS]

[NAME OF INVENTION]

Phase Shift Laser Mask and sequential lateral solidification Crystallization Method using by the same

[BRIEF EXPLANATION OF FIGURES]

FIG. 1 is a crystallization curve graph of silicon classified by energy intensity.

FIG. 2 is a schematic view showing a SLS crystallizing process using a laser annealing method according to the related art.

FIG. 3 is a cross-sectional view showing a specific laminated structure about a portion of a laser mask according to the related art.

FIG. 4 shows overlaps between shots of a laser beam in a SLS crystallizing process using the mask of FIG. 3.

FIG. 5 is a schematic view illustrating a principle of phase shift in a mask according to the present invention.

FIG. 6 is a plan view of a phase shift laser mask for crystallizing amorphous silicon according to an exemplary embodiment of the present invention.

FIG. 7 is a cross-sectional view along the line VI-VI of FIG. 6.

FIG. 8 is a schematic view showing energy intensity profiles of a laser beam irradiated through the mask of the present invention.

FIG. 9 is a flow chart showing a SLS crystallizing process using the mask of the present invention.

* Explanation of major parts in the figures *

100 : base substrate
112 : phase shift layer
114 : laser blocking layer
116 : slit
W1 : first width
W2 : second width
W3 : third width
V : both sides

[DETAILED DESCRIPTION OF INVENTION]

[OBJECT OF INVENTION]

[TECHNICAL FIELD OF THE INVENTION AND PRIOR ART OF THE FIELD]

The present invention relates to a method of crystallizing amorphous silicon. More particularly, the present invention relates to a laser mask for crystallizing the amorphous silicon and a method of crystallizing using the same.

Recently, a liquid crystal display (LCD) device has been in the spotlight as a next generation display device having high value added because of its low power consumption and good portability.

The liquid crystal display device is composed of an array substrate including thin film transistors, a color filter substrate and a liquid crystal layer interposed between the array substrate and the color filter substrate. The liquid crystal display device displays images by using transmittance of light depending on an anisotropic refractive index of the liquid crystal layer.

An active matrix liquid crystal display (AMLCD) device, which includes a thin film transistor (TFT) at each pixel as a switching device, has been widely used due to its high resolution and fast moving images.

In general, silicon may be used as an active layer of the thin film transistor. Since polycrystalline silicon has a high filed effect mobility and is optically stable, polycrystalline silicon is widely used as an active layer of a thin film transistor for a liquid crystal display device that includes driving circuits and the film transistor on the same substrate or for a display device that may be much exposed to light.

Polycrystalline silicon may be formed through a high temperature process or a low temperature process. The high temperature process may be accomplished under temperatures of about 1,000 degrees of Celsius, which are much higher than a transition temperature of an insulating substrate such as a glass substrate. Therefore, the high temperature process requires a quartz substrate that has a high resistance in heat. However, the quartz substrate is high-priced. In addition, a polycrystalline silicon layer formed through the high temperature process has a high surface roughness and comprises fine grains.

Accordingly, a method of forming polycrystalline silicon, which includes depositing amorphous silicon that can be formed under low temperature and crystallizing the amorphous silicon, has been researched and developed.

The method of forming polycrystalline silicon includes a laser annealing method and a metal induced crystallization method.

Among these methods, in the laser annealing method, pulses of laser beams are irradiated on a substrate including an amorphous silicon layer, and melting and solidification of the irradiated amorphous silicon layer are repeatedly accomplished in 10 to 10^2 nanoseconds. Thus, damage to the substrate under the silicon layer may be minimized.

A method of crystallizing amorphous silicon will be described in detail with reference to the attached drawings.

FIG. 1 is a crystallization curve graph of silicon classified by energy intensity. A laser crystallization region is defined by a size of a grain.

As show in FIG. 1, a first region of the graph is a partial melting regime. Only a surface of a silicon layer is melted by the energy intensity of the first region, thereby forming small grains.

A second region of the graph is a near-complete melting regime. Grains formed by the second region are lager than those by the first region because the grains laterally grow. However, the grains have non-uniform sizes.

A third region of the graph is a complete melting regime, wherein an amorphous silicon layer is wholly melted by the energy intensity of the third region and fine grains are formed due to homogeneous nucleation.

Thus, in the laser annealing method, in order to form uniform and large grains, the energy intensity of the second region may be used, and irradiation times and overlapping ratios of laser beams may be controlled.

Generally, a plurality of grain boundaries of polycrystalline silicon interferes with currents and lowers reliability of a thin film transistor. In addition, there may be breakdown of an insulating layer because of collision of electrons and deterioration in the grains.

Accordingly, the formation of single crystalline silicon is important, and recently, a sequential lateral solidification (SLS) method has become of interest to solve the above problems. The SLS method takes advantage of the fact that silicon grains grow laterally from the boundary between liquid silicon and solid phase silicon. The SLS method can increase the size of the silicon grains that grow by controlling the energy intensity of a laser beam and the irradiation range of the laser beam (reference, Robert S. Sposilli, M. A. Crowder, and

James S. Im, Mat. Res. Soc. Symp. Proc. Vol. 452, 956~957, 1997). This enables TFTs having channel areas of single crystalline silicon.

FIG. 2 is a schematic view showing a SLS crystallizing process using a laser annealing method according to the related art. In FIG. 2, a laser mask 14, which includes slits 12 spaced apart from each other, is disposed over a silicon layer 10 of amorphous phase. After a laser shot 16 is irradiated on portions of the silicon layer 10 through the slits 12 of the laser mask 14, it is shown that a SLS crystallizing process defining a silicon region I of single crystal state by crystallizing a portion of the silicon layer 10 corresponding to the slit 12 by irradiating a laser shot 16 through the slits 12 of the laser mask 14.

When the SLS crystallizing process is specifically explained, as seeds are formed at both sides of portion that the laser shot 16 is irradiated by irradiating the laser shot 16 having an energy intensity that enables to completely melt a portion of the silicon layer 10 of amorphous state through the laser mask 14 having the slits 12, a step of developing as a single crystal using the seeds as a crystal core along facing directions. At this time, the seeds 18 created at the both sides of the irradiated silicon layer by the laser shot 16 is crystallized along a facing direction and stop the growth at facing point. A width from one boundary of the portion I to the region II where the growth of the seeds 18 stop may be referred to as a length L of the seeds 18.

Although not shown in the figure, the laser mask 14 is moved so that the laser mask 14 overlap a generation portion of the seeds 18. As a laser shot is irradiated on the next portion of the silicon layer 10, a silicon layer 10 of a single crystal state is formed by artificially being extended a side growth.

The processes are performed until the length of the grain is about 10 μm, and the silicon layer including the grains may be used as an active layer of a thin film transistor, which has a channel of about 6 μm in width.

FIG. 3 is a cross-sectional view showing a specific laminated structure about a portion of a laser mask according to the related art.

As shown in FIG. 3, laser blocking layers 22 spaced apart from each other are formed on a base substrate 20. Spaces between the laser blocking layers 22 are defined as slits 24. The base substrate 20 may be made of quartz, and the laser blocking layers 22 may be made of chromium (Cr), which reflects a laser beam. The laser blocking layers 22 may have a width of about 4 μm and the slits 24 may have a width of about 2 μm.

FIG. 4 shows overlaps between shots of a laser beam in a SLS crystallizing process using the mask of FIG. 3. A profile of the laser beam at each shot relates to an energy intensity of the laser beam. FIG. 4 illustrates the region corresponding to only two slits of the mask for convenience sake of explanation.

As shown in FIG. 4, a first laser shot is performed on the substrate 28 including an amorphous silicon layer 26 thereon and a beam passing through the mask has two peaks corresponding to the slits. Second, third and fourth laser shots are subsequently carried out such that peaks of each laser shot overlap each other. At this time, the peaks overlap each other such that the overlapped portions between the peaks can have energy intensities higher than melting point of the silicon layer 26.

The peaks of the first laser shot to the fourth laser shot overlap each other with a fixed width because a position the substrate 20 corresponding to the slit of the mask changes by moving the substrate in a first direction in the context of the figure. In FIG. 4, a second direction, which is opposite to the first direction, indicates a growing direction of grains.

Although not shown in the figure, a distance IV between the two peaks of the first laser shot is closely connected with the width of the laser blocking layer 22 of the mask 20 of FIG. 3, i.e., a space between the slits 24 of FIG. 3. Since the peaks of each laser shot should have the distance IV therebetween to prevent overlapping each other, there is a limitation in reducing the width of the laser blocking layer 22 under 4 μm according to the structure of the mask of the related art.

More particularly, in the SLS crystallizing process using the mask of the related art, if the peaks of a laser shot overlap each other, the silicon layer is melted non-uniformly because an overlapping portion between the peaks is large, and thus grains dose not grow completely. In addition, since a nucleation region is formed in the overlapping portion, characteristics of crystallization get worse. Therefore, the width of the blocking layer, that is, the space between the slits should be so more than at least 4 μm that the peaks of each laser shot should not overlaps each other, thereby providing a reliable process. However, there is a disadvantage that efficiency of the process is lowered due to increasing of laser shots.

[TECHNICAL SUBJECT OF INVENTION]

To solve the problems, the present invention has an object that provides a laser mask and a method of crystallizing the same that can make a number of laser shot reduce without changing an optical system.

For this object, as the laser mask according to the present invention includes a phase shift layer that can shift phase difference of the laser beam excluding the laser blocking layer an interval space between the slits of the laser mask, the SLS crystallization process can be performed using a small shot of a laser mask having a high resolution by preventing overlap between the same shots as well as making narrow the interval space between slits.

The phase shift laser mask according to the present invention has a feature such that a phase shift layer is formed on a general mask substrate and makes a phase of the laser beam inverse or shift.

FIG. 5 is a schematic view illustrating a principle of phase shift in a mask according to the present invention.

In FIG. 5, a first part 54a of a laser beam 54 passes through a first portion of a mask 50, where there is no layer, and a second part 54b of the laser beam 54 permeates a second portion of the mask 50, where there exists a phase shift layer 52. Since the first part 54a and the second part 54b of the laser beam 54 go through different optical paths according to the existence of the phase shift layer 52, there is a phase difference $\Delta\Phi$ between the first part 54a and the second part 54b passing through the mask 50. The phase difference $\Delta\Phi$ is expressed as the following equation:

$$\Delta\Phi = 2\pi \cdot d(n-1) \cdot \lambda \quad \text{------------------} \text{ (formula 1)}$$

(wherein λ is a wavelength of a light source, n is a refractive index of the phase shift layer 52, and d is a thickness of the phase shift layer 52)

Thus, from the above equation, the phase of light can be shifted by about 180 degrees, for example, by controlling the thickness d of the phase shift layer 52.

[CONSTRUCTION AND OPERATION OF INVENTION]

To achieve the objectives of the present invention, in a first characteristic according to the present invention, a phase shift laser mask for fabricating a crystallization silicon using a laser apparatus having a complete melting energy intensity includes: a base substrate; a plurality of phase shift layers having a first width along a first direction on the base substrate, the plurality of phase shift layers spaced apart from each other; a plurality of laser blocking layer overlapped the plurality of the phase shift layers along the first direction, the plurality of the laser blocking layers including a second width narrower than the first width; and a slit in an interval space between the plurality of the phase shift layers.

The phase shift layer is made of a material having parity for a phase difference, the phase shift layer includes molybdenum silicide (MoSix), the laser blocking layer is made of a material having a reflectivity for a laser beam, and the laser blocking layer includes chromium (Cr).

The slit has a formation width within a range about 1 μm to about 3 μm, the first width is within a range about 1 μm to about 3 μm, the laser blocking layer is overlapped with a center portion of the phase shift layer, thereby exposing both side portions of the phase shift layer, the formation width of the slit is equal to the first width, and the laser apparatus is an excimer laser apparatus.

In a second characteristic according to the present invention, a method of fabricating a sequential lateral solidification crystallization using a phase shift laser mask, comprising: forming an amorphous silicon layer on a substrate; locating a phase shift laser mask that includes a base substrate, a plurality of phase shift layers having a first width along a first direction on the base substrate, the plurality of phase shift layers spaced apart from each other, a plurality of laser blocking layer overlapped the plurality of the phase shift layers along the first direction, the plurality of the laser blocking layers including a second width narrower than the first width, and a slit in an interval space between the plurality of the phase shift layers; irradiating a laser shot having an energy intensity corresponding to a complete melting region onto the substrate having the amorphous silicon layer through the slit of the phase slit laser mask; and crystallizing the amorphous silicon layer through overlapping the laser shot, wherein both sides of an energy intensity profile of the laser shot having a steep slope through inversion of phase difference in the phase shift layer of the phase shift laser mask.

The base substrate is made of a thermal resistance material, the base substrate includes quartz, the phase shift layer includes molybdenum silicide ($MoSi_x$), the laser blocking layer is made of a material that enables to block a laser beam, the laser blocking layer includes chromium (Cr).

The slit has a formation width within a range about 1 μm to about 3 μm, the formation width of the phase shift layer has a width within a range about 1 μm to about 3 μm, the formation width of the slit is equal to the width of the phase shift layer, laser blocking layer is overlapped with a center portion of the phase shift layer, thereby exposing both sides of the phase shift layer, the first width is about 2 μm and the formation width of the slit is about 2 μm, the laser shot includes first and second laser shots.

The phase shift layer has an exposure degree within a range that enable to inverse a laser profile in an energy intensity region higher than a complete melting intensity of a silicon layer.

Hereinafter, an exemplary embodiment will be specifically explained referring to figures.

FIG. 6 is a plan view of a phase shift laser mask for crystallizing amorphous silicon according to an exemplary embodiment of the present invention.

In FIG. 6, a phase shift layer 112 having a first width W1 is formed in a first direction on a base substrate 110, a laser blocking layer 114 having a second width W2 is formed in the first direction and overlaps with the phase shift layer 112, and a slit 116 having a third width W3 is formed in spaces between adjacent phase shift layers 112.

Here, the second width W2 is narrower than the first width W1, thereby exposing both sides V of each first stripe of the phase shift layer 112. The exposed sides V of the phase shift layer 112 causes phase shift of a laser beam passing therethrough when the laser beam is irradiated, and thus profiles of the laser beam passing through the mask can have a sharpened slope.

In general, the first width W1 may be twice as wide as the third width W3, but the first width W1 and the third width W3 may be equal in the present invention.

The mask of the present invention may be used for an excimer laser apparatus.

FIG. 7 is a cross-sectional view along the line VI-VI of FIG. 6.

As shown in FIG. 7, the phase shift layer 112 having a first width W1 is formed on the base substrate 110. The phase shift layers 112 are spaced apart from each other. The laser blocking layer 114 having the second width W2 is formed on the phase shift layer 112, wherein the second width W2 is narrower than the first width W1, thereby exposing both sides V of the phase shift layer 112 by the laser blocking layer 114.

A slit 116 is defined in an interval space between the phase shift layer 112.

The phase shift layer 112 may be made of a material that can reverse the phase of light, such as $MoSi_x$ (molybdenum-silicide), for example. The base substrate 110 may be made of a high heat-resistant material, such as quartz, and the blocking layer 114 may be made of a material that can prevent light, such as chromium (Cr), for example.

In the mask of the present invention, the third width W3 of the slit 116 may be within a range of about 1 μm to about 3 μm and the first width W1 of the phase shift layer 112 may be also within a range of about 1 μm to about 3 μm. Here, it is beneficial that the third width

W3 and the first width W1 may be about 2 μm. Accordingly, in the present invention, the resolution of the mask for crystallizing can be improved due to destructive interference of the beam profile by using the phase shift layer without change of optical compensating apparatus for controlling the laser beam. Therefore, the productivity in the SLS crystallizing method can be increased due to the mask having an improved resolution.

The exposed sides V of the phase shift layer 112 should have so sizes that the transmitted laser beam may be reversed to have energy intensities larger than the melting point of a silicon layer.

FIG. 8 is a schematic view showing energy intensity profiles of a laser beam irradiated through the mask of the present invention.

In FIG. 8, a first laser shot is irradiated on the substrate 122 including an amorphous silicon layer 120 thereon, and then a second laser shot is irradiated on an interval space between the first laser shots.

In the SLS crystallizing process of the present invention, peaks of each laser shot do not overlap each other because profiles of the laser beam passing through the mask have sharpened slopes due to destructive interference by using the phase shift layer. Therefore, the number of laser shots is decreased as compared with the related art. In addition, since the distance between the slits can be reduced and the number of slits can be increased, the resolution of the mask for crystallizing can be improved.

Accordingly, although the mask may have the resolution of about 2 μm, for example, the profiles of the laser beam do not overlap each other, and thus grains can grow stably and reproductively.

Accordingly, the problems that crystal characteristic gets worse due to a core creation region in an overlap portion such as the related art can be solved.

Therefore, a number of laser shot can be reduced in the crystallization process, the sequential lateral solidification crystallization (SLS) grains can be formed through irradiation of the second laser shot between the first laser shots.

However, the overlap number between laser shots according to the present invention is not limited to two times but decreased as against the related art, thereby improving productivity of the SLS crystallizing process.

FIG. 9 is a flow chart showing a SLS crystallizing process using the mask of the present invention.

At the step ST1, an amorphous silicon layer is formed by depositing amorphous silicon on an insulating substrate and dehydrogenating the amorphous silicon to improve crystallizing characteristics. Here, a buffer layer may be formed between the substrate and the amorphous silicon layer. The buffer layer may be made of an insulating material such as silicon oxide (SiO_2).

At the step ST2, the SLS crystallizing process is performed using a laser. That is, a first shot of a laser beam is performed on the substrate including the amorphous silicon layer by using the mask including a phase shift layer, and a portion exposed to the laser beam is melted. Seeds be created from the boundaries of the melted portion toward the middle of the melted portion, and thus a first crystallized region is formed. The next shot is carried out, wherein the transmitted laser beam overlaps the first crystallized region.

At the step ST3, a polycrystalline silicon layer is formed by repeatedly performing the step ST2.

In the mask of the present invention, the blocking layer that is made of chromium reflects the laser beam and the phase shift layer made of molybdenum silicide reverses a phase of the laser beam, reducing the intensity of the laser beam. Therefore, peaks of a laser shot can be separated without difficulty.

Additionally, the resolution of the mask for crystallizing can be improved, and thus productivity of the SLS crystallizing process can be increased.

It will be apparent to those skilled in the art that various modifications and variations can be made in the fabrication and application of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

[EFFECT OF INVENTION]

As the explained above, the SLS crystallization process using the phase shift laser mask according to the present invention, thereby improving productivity of the SLS crystallization process due to improved resolution of the laser beam.

[RANGE OF CLAIMS]

[CLAIM 1]

A phase shift laser mask for fabricating a crystallization silicon using a laser apparatus having a complete melting energy intensity, comprising:

a base substrate;

a plurality of phase shift layers having a first width along a first direction on the base substrate, the plurality of phase shift layers spaced apart from each other;

a plurality of laser blocking layer overlapped the plurality of the phase shift layers along the first direction, the plurality of the laser blocking layers including a second width narrower than the first width; and

a slit in an interval space between the plurality of the phase shift layers.

[CLAIM 2]

The mask according to claims 1, wherein the phase shift layer is made of a material having parity for a phase difference.

[CLAIM 3]

The mask according to claims 2, wherein the phase shift layer includes molybdenum silicide (MoSix).

[CLAIM 4]

The mask according to claims 1, wherein the laser blocking layer is made of a material having a reflectivity for a laser beam.

[CLAIM 5]

The mask according to claims 4, wherein the laser blocking layer includes chromium (Cr).

[CLAIM 6]

The mask according to claims 1, wherein the slit has a formation width within a range about 1 μm to about 3 μm.

[CLAIM 7]

The mask according to claims 1, wherein the first width is within a range about 1 μm to about 3 μm.

[CLAIM 8]

The mask according to claims 1, wherein the laser blocking layer is overlapped with a center portion of the phase shift layer, thereby exposing both side portions of the phase shift layer.

[CLAIM 9]

The mask according to claims 1, wherein the formation width of the slit is equal to the first width.

[CLAIM 10]

The mask according to claims 1, wherein the laser apparatus is an excimer laser apparatus.

[CLAIM 11]

A method of fabricating a sequential lateral solidification crystallization using a phase shift laser mask, comprising:

forming an amorphous silicon layer on a substrate;

locating a phase shift laser mask that includes a base substrate, a plurality of phase shift layers having a first width along a first direction on the base substrate, the plurality of phase shift layers spaced apart from each other, a plurality of laser blocking layer overlapped the plurality of the phase shift layers along the first direction, the plurality of the laser blocking layers including a second width narrower than the first width, and a slit in an interval space between the plurality of the phase shift layers;

irradiating a laser shot having an energy intensity corresponding to a complete melting region onto the substrate having the amorphous silicon layer through the slit of the phase slit laser mask; and

crystallizing the amorphous silicon layer through overlapping the laser shot,

wherein both sides of an energy intensity profile of the laser shot having a steep slope through inversion of phase difference in the phase shift layer of the phase shift laser mask.

[CLAIM 12]

The method according to claim 11, wherein the base substrate is made of a thermal resistance material.

[CLAIM 13]

The method according to claim 12, wherein the base substrate includes quartz.

[CLAIM 14]

The method according to claim 11, wherein the phase shift layer includes molybdenum silicide ($MoSi_x$).

[CLAIM 15]

The method according to claim 11, wherein the laser blocking layer is made of a material that enables to block a laser beam.

[CLAIM 16]

The method according to claim 15, wherein the laser blocking layer includes chromium (Cr).

[CLAIM 17]

The method according to claim 11, wherein the slit has a formation width within a range about 1 μm to about 3 μm.

[CLAIM 18]

The method according to claim 11, wherein the formation width of the phase shift layer has a width within a range about 1 μm to about 3 μm.

[CLAIM 19]

The method according to claim 11, wherein the formation width of the slit is equal to the width of the phase shift layer.

[CLAIM 20]

The method according to claim 11, wherein the laser blocking layer is overlapped with a center portion of the phase shift layer, thereby exposing both sides of the phase shift layer.

[CLAIM 21]

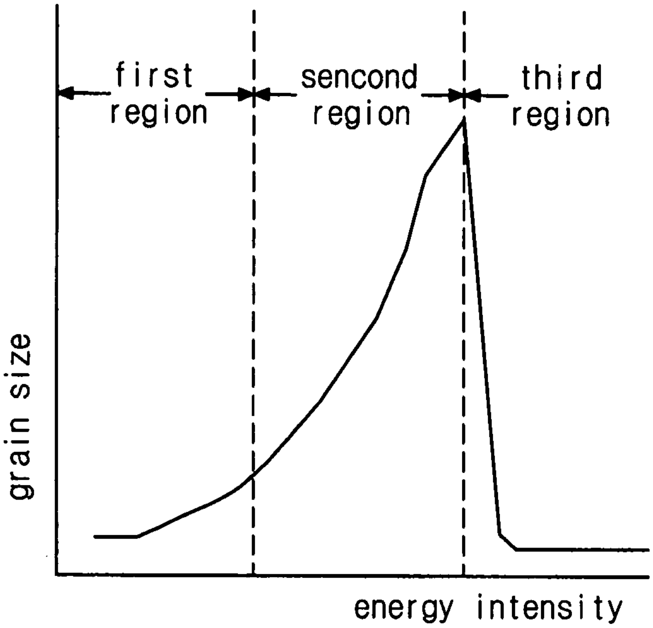
The method according to claim 11, wherein the first width is about 2 μm and the formation width of the slit is about 2 μm, the laser shot includes first and second laser shots.

[CLAIM 22]

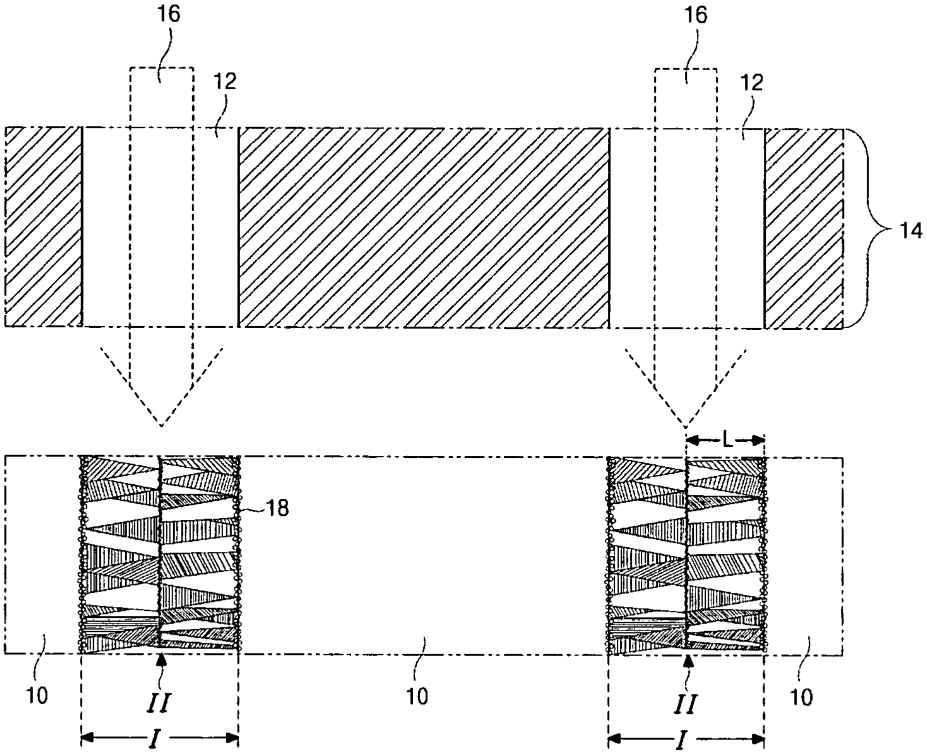
The method according to claim 11, wherein the phase shift layer has an exposure degree within a range that enable to inverse a laser profile in an energy intensity region higher than a complete melting intensity of a silicon layer.

[DRAWINGS]

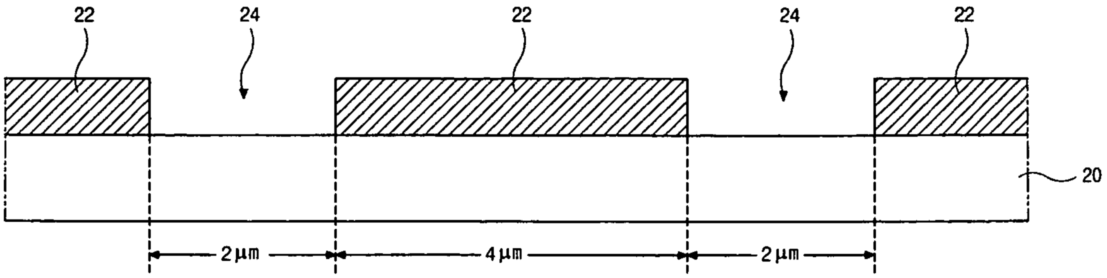
[FIG. 1]



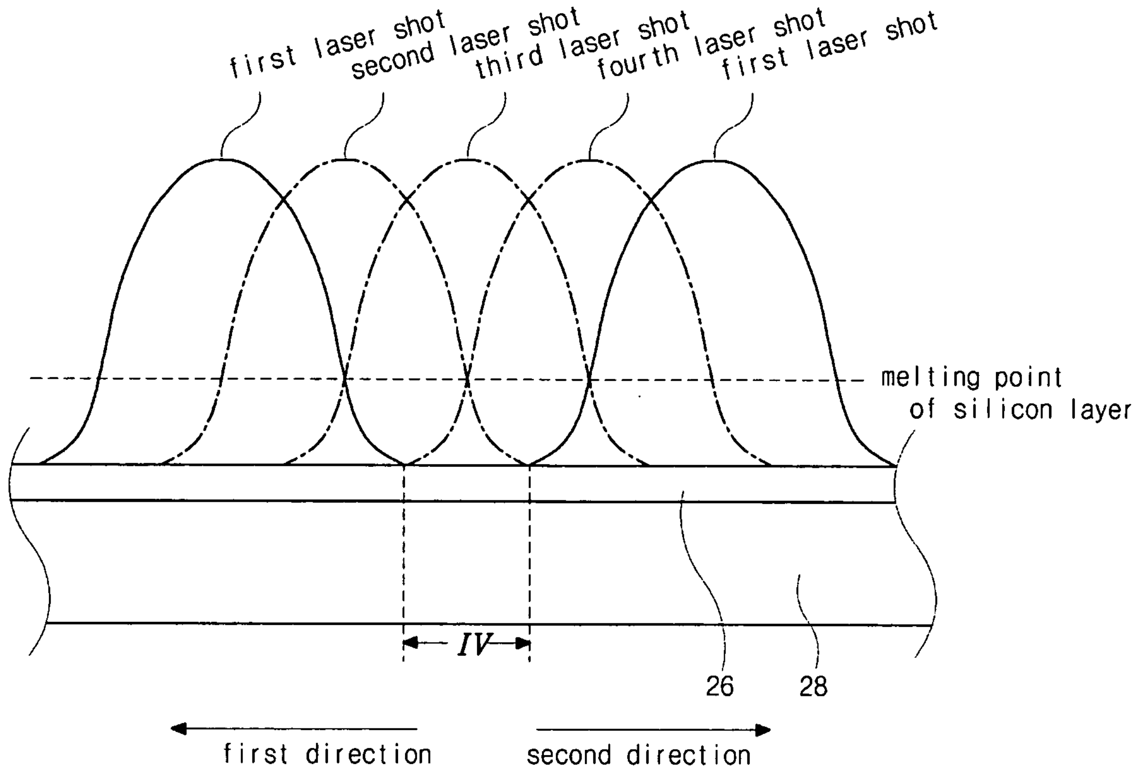
[FIG. 2]



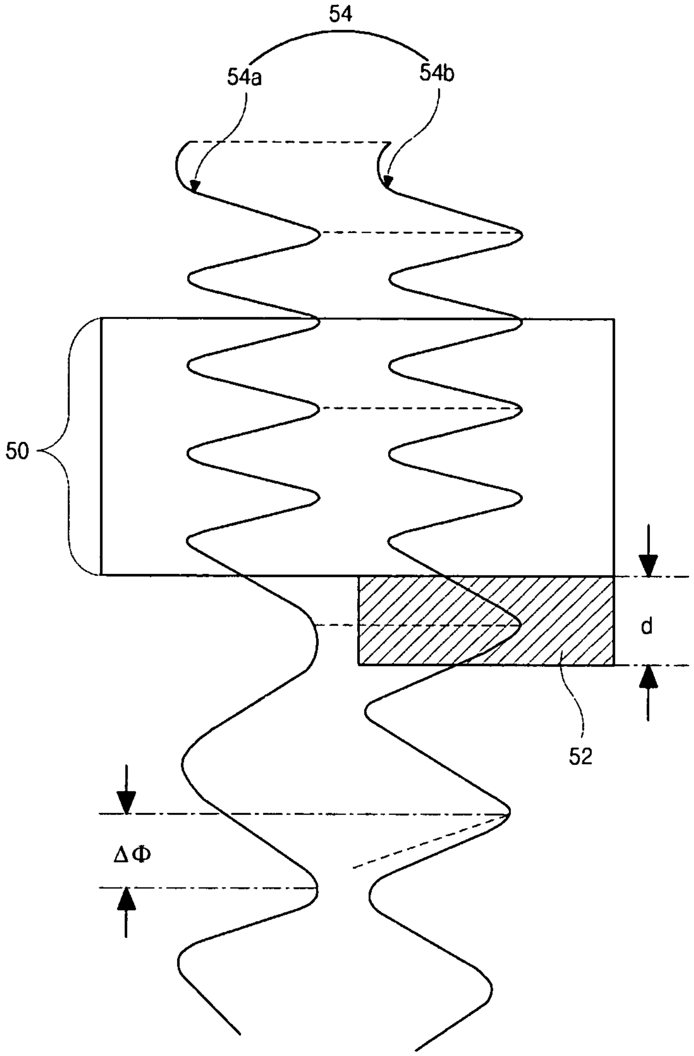
[FIG. 3]



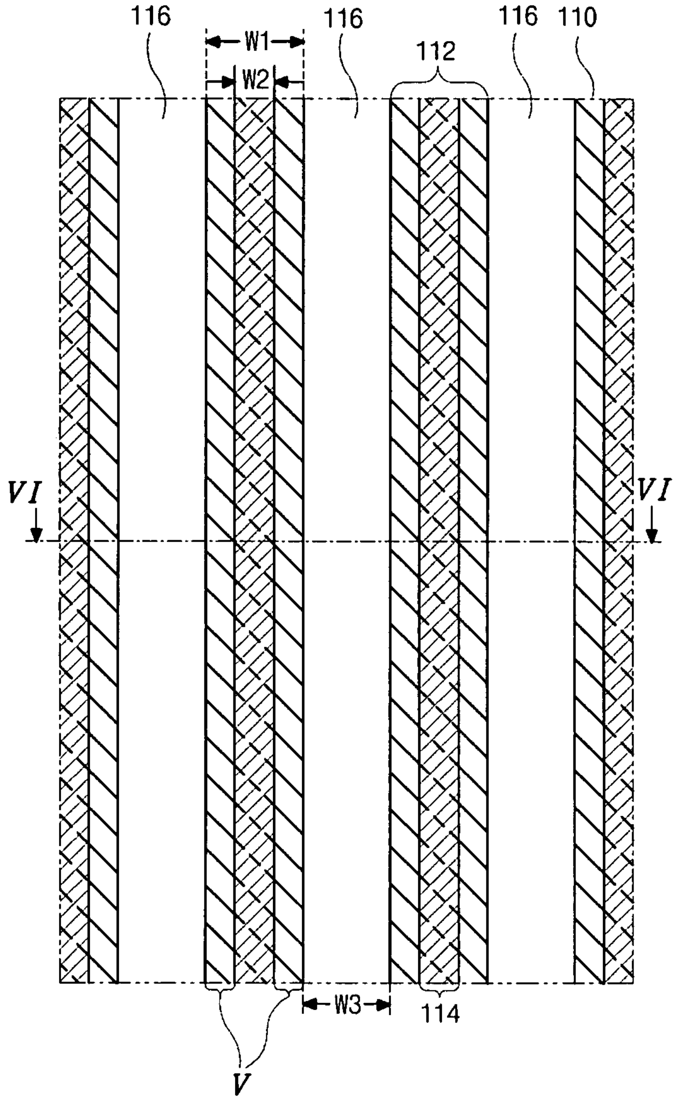
[FIG. 4]


first laser shot
second laser shot
third laser shot
fourth laser shot
first laser shot
melting point of silicon layer
IV
26
28
first direction
second direction

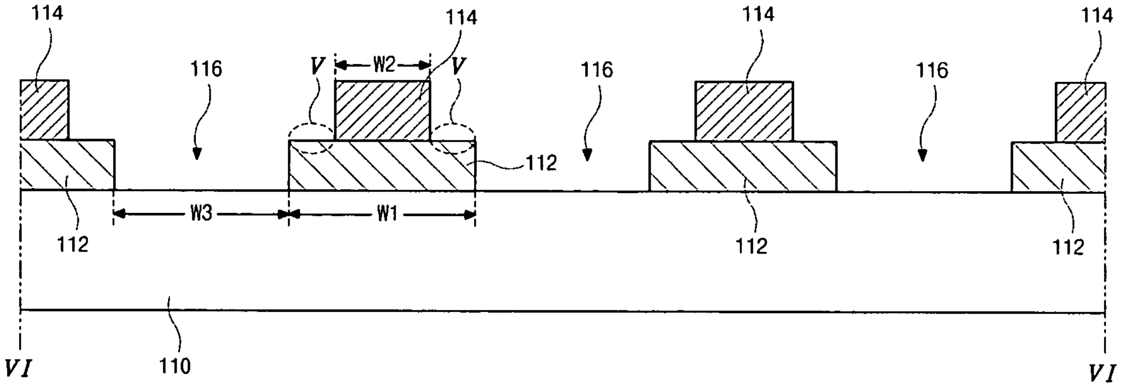
[FIG. 5]



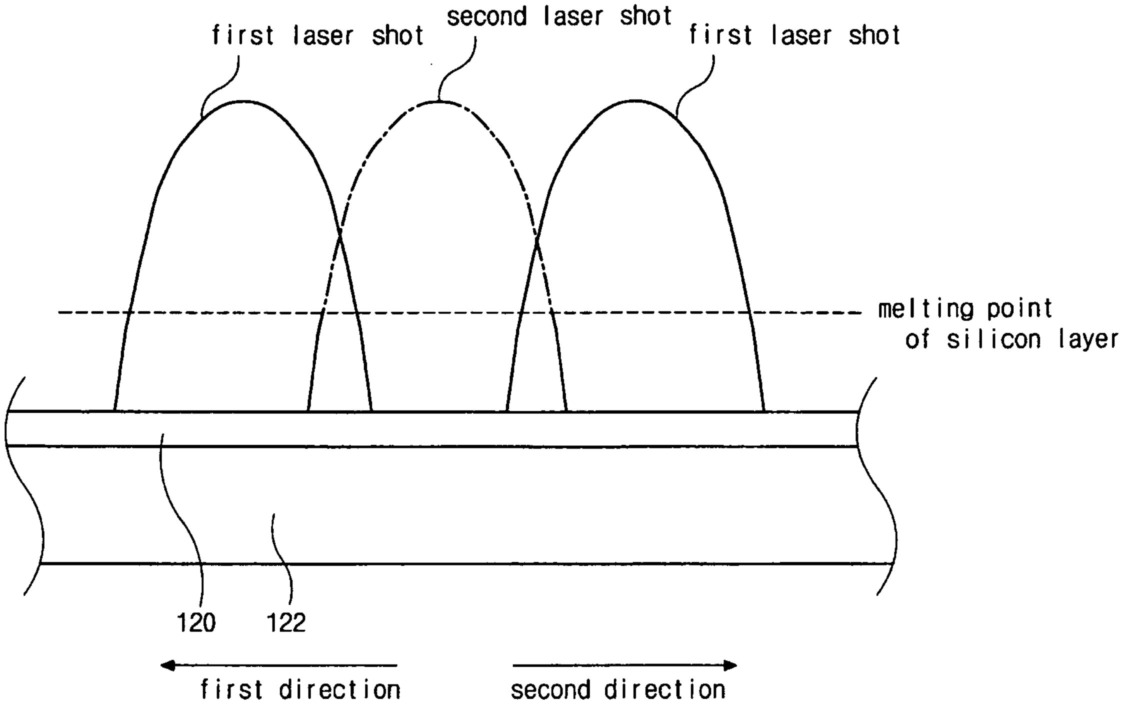
[FIG. 6]



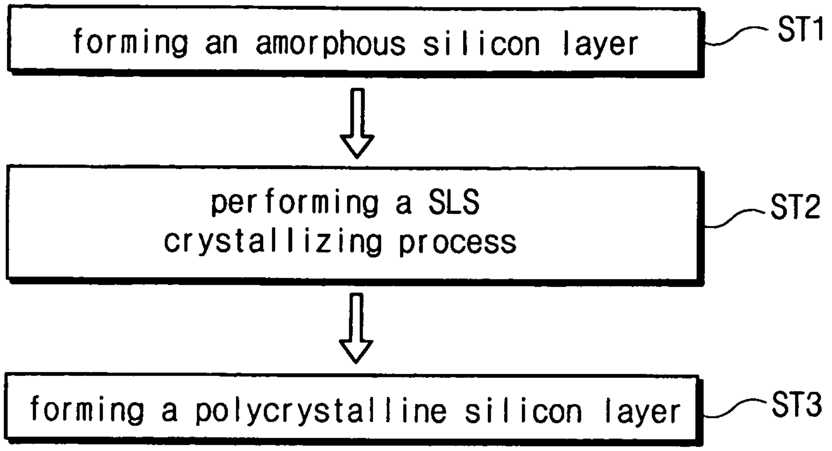
[FIG. 7]



[FIG. 8]


first laser shot
second laser shot
first laser shot
melting point of silicon layer
120
122
first direction
second direction

[FIG. 9]


forming an amorphous silicon layer
ST1
performing a SLS crystallizing process
ST2
forming a polycrystalline silicon layer
ST3